An In-Beam Measurement of the Position Resolution in a Highly Segmented Co-axial Ge detector

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Gamma-ray energy tracking detector arrays [1] that are based on multiple highly-segmented coaxial Ge crystals (e.g. GRETINA/GRETA or AGATA) have the capability to resolve individual γ–ray interactions within the crystal and to track these interactions both within and across crystal boundaries. By analyzing the signal shapes from the segments it is possible to determine the interaction location to a far greater accuracy than the segment size and achieve millimeter position resolutions from centimeter size segments.

We report on an in-beam measurement of the position resolution of the 36-fold segmented GRETA II prototype detector [2]. The aim was to demonstrate feasibility to accurately locate the positions of individual gamma-ray interactions under realistic (in-beam) conditions and provide a measurement of the position resolution. A 385 MeV ^{82}Se beam provided by the Lawrence Berkeley National Laboratory 88-Inch Cyclotron bombarded a thin ^{12}C target producing ^{90}Zr with β=8.76%. The detector was at 90 degrees to the beam direction and 4 cm from the target center. The reaction and experimental setup were chosen to maximize the Doppler broadening. Three LBNL 8-channel digital signal processing boards instrumented 24 segments. The position of the first γ–ray interaction was determined by comparing the measured pulse shapes of both net and induced signals to a set of pre-calculated basis signals (signal decomposition) and the γ–ray energy spectrum was Doppler corrected event-by-event. The measured peak width of a γ–ray emitted in flight is then directly related to how well the location of the first interaction is determined.

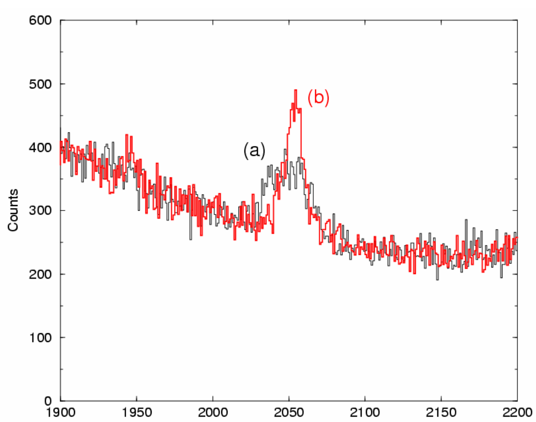

FIG. 1: Spectra obtained using the 36-segmented GRETA II prototype detector following the reaction ^{12}C(^{82}Se,4n)^{90}Zr at 385MeV. The peak at 2055 keV corresponds to the decay of the 10^{+} state and is Doppler corrected (a) assuming the interaction occurred at the center of a segment, and (b) after signal decomposition.

Fig. 1 shows Doppler corrected spectra for the 2055 keV γ–ray in ^{90}Zr (a) assuming the interaction occurred at the center of a segment, and (b) after signal decomposition. The peak width decreases from 29 keV to14.5 keV when signal decomposition is used. For this analysis we considered multiple interactions in one segment. To estimate the position resolution we simulate our experimental setup and calculated the expected peak width for a 2055 keV γ–ray as function of position resolution. This curve is shown in Fig. 2. The observed width of 14.5 keV corresponds to a position resolution σ = 2.5mm (RMS value in 3-dimensions).

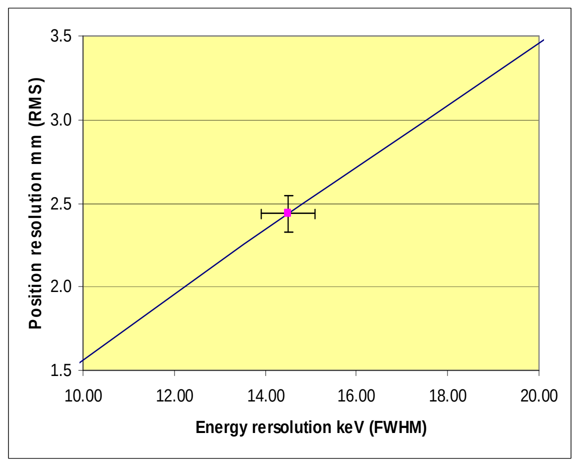

FIG. 2: Plot of the expected energy resolution as a function of the position resolution for the experimental setup described in the text. The solid line was obtained from simulation. The data point is for the measured energy resolution of 14.5 keV seen in figure 1 (spectrum b) and corresponds to a position resolution of ~2.5 mm.

REFERENCES

[1] I.Y.Lee, NIM A422 (1999) 195; M.A.Deleplanque et al., NIM A430 (1999) 292.

[2] K.Vetter et al., NIM A452 (2000) 105